CLAIMS

1. An electrochemical device, comprising:

a electrolyte including one or more polysiloxanes, one or more alkali metal salts, and one or more silanes.

2. The device of claim 1, wherein at least one polysiloxane is cyclic.

3. The device of claim 1, wherein at least one polysiloxane has a backbone that includes one or more silicons linked to one or more side chains that include a poly(alkylene oxide) moiety.

4. The device of claim 1, wherein at least one polysiloxane has a backbone that includes one or more silicons linked to one or more side chains that include a carbonate moiety.

5. The device of claim 3, wherein one or more of the backbone silicons are linked to a plurality of side chains that each include a poly(alkylene oxide) moiety.

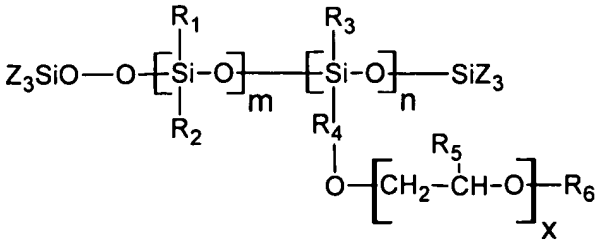
6. The device of claim 3, wherein an organic spacer is positioned between the backbone silicons and the poly(alkylene oxide) moiety.

7. The device of claim 3, wherein the spacer includes oxygen linked to the backbone silicons.

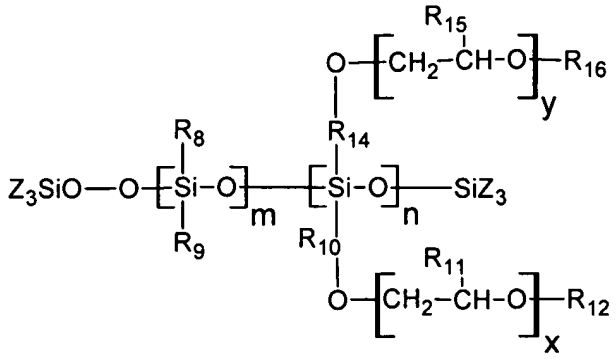
8. The device of claim 1, wherein the silane includes at least one substituent that includes a moiety selected from a first group consisting of an alkyl group, an aryl group, an alkoxy group, an alkylene oxide group or a poly(alkylene oxide) and at least one substituent that includes a moiety selected from a second group consisting of an alkoxy group, a carbonate group, an alkylene oxide group and a poly(alkylene oxide) group.

9. The device of claim 8, wherein the silane includes four substituents that each includes a moiety selected from the first group or from the second group.

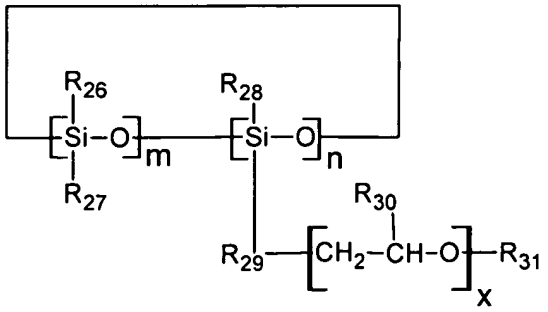
10. The device of claim 1, wherein at least one polysiloxane has a structure selected from a group consisting of structures represented by formula I-a through formula I-d:



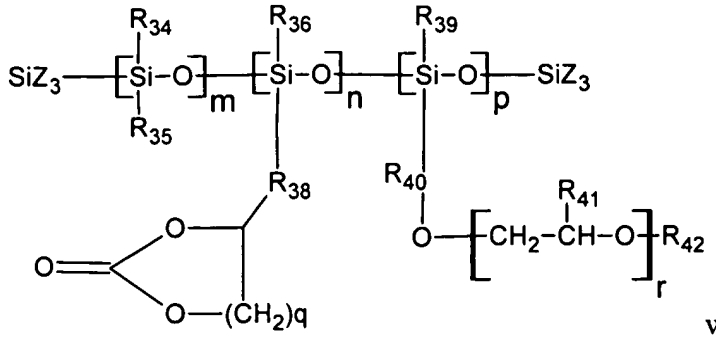
formula I-a: where R_1 is an alkyl group, R_2 is an alkyl group or an alkoxy group, R_3 is an alkyl group, R_4 is nil or an organic spacer, R_5 is a hydrogen atom or an alkyl group, and R_6 are alkyl groups, Z is an alkyl or an aryl group, m is from 0 to 15, n is from 1 to 30, x is from 2 to 15;



formula I-b: wherein R_8 is an alkyl group, R_9 is an alkyl group or an alkoxy group, R_{10} is nil or an organic spacer, R_{11} is a hydrogen or an alkyl group, R_{12} is an alkyl group, R_{14} is nil or an organic spacer, R_{15} is a hydrogen or an alkyl group, R_{16} is an alkyl group, Z is an alkyl or an aryl group, m is from 0 to 15, n is from 1 to 30, x is from 2 to 15; and



formula I-c: wherein, R_{26} is an alkyl group, R_{27} is an alkyl group or an alkoxy group, R_{28} is an alkyl group, R_{29} is an oxygen or an organic spacer, R_{30} is a hydrogen atom or an alkyl group, R_{31} is alkyl group, m is 0 or greater than 0, n is from 3 to 10, and x is from 2 to 15; and

formula I-d:  where, R_{34} is an alkyl group; R_{35} is an alkyl group or an alkoxy group; R_{36} is an alkyl group; R_{38} is nil an oxygen or an organic spacer; R_{39} is an alkyl group; R_{40} is nil or an organic spacer; R_{41} is a hydrogen or an alkyl group; R_{42} is an alkyl group; Z is an alkyl or an aryl group; m is 0 or greater than 0; n is 1 to 30; p is 0 or greater than 0; q is 1 or 2; r is 2 to 15.

11. The device of claim 10, wherein m is 0.

12. The device of claim 10, wherein R_4, R_{10}, $R1_{14}$, R_{29}, R_{38} and R_{40}, are nil.

13. The device of claim 10, wherein R_4, R_{10}, $R1_{14}$, R_{29}, R_{38} and R_{40}, are an organic spacer.

14. The device of claim 13, wherein the organic spacer includes an oxygen linked to a silicon on the backbone of the polysiloxane.

15. The device of claim 10, wherein at least one polysiloxane has a structure selected from the group consisting of structures represented by formula I-a.

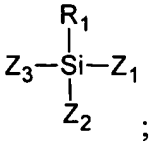
16. The device of claim 10, wherein at least one polysiloxane has a structure selected from the group consisting of structures represented by formula I-b.

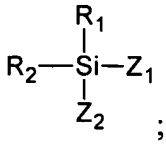
17. The device of claim 10, wherein at least one polysiloxane has a structure selected from the group consisting of structures represented by formula I-c.

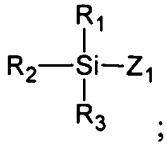
18. The device of claim 10, wherein at least one polysiloxane has a structure selected from the group consisting of structures represented by formula I-d.

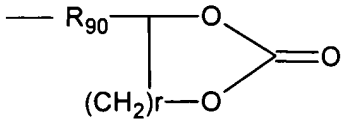
19. The device of claim 18, wherein p is 0.

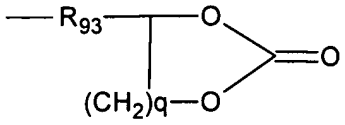
20. The device of claim 1, wherein at least one silane has a structure selected from a group consisting of structures represented by formula II-a through formula II-c;

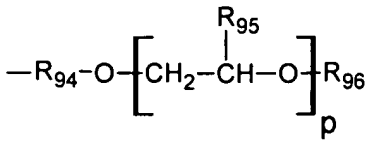
formula II-A:  ;

formula II-B:  ;

formula II-C:  ; wherein, R_1 is an alkyl, aryl, an alkoxy, or is represented by formula II-D; R_2 is an alkyl, aryl, an alkoxy or is represented by formula II-D; R_3 is an alkyl, aryl, an alkoxy, or is represented by formula II-D; Z_1 is an alkoxy, is represented by formula II-E or is represented by formula II-F; Z_2 is an alkoxy, is represented by formula II-E or is represented by formula II-F; Z_3 is an alkoxy, is represented by formula II-E or is represented by formula II-F;

formula II-D:  : wherein R_{90} is oxygen or an organic spacer and r is 1 or 2;

formula II-E:  : wherein R_{93} is oxygen or an organic spacer and q is 1 or 2; and

formula II-F:  : wherein R_{94} is nil or an organic spacer; R_{95} is hydrogen; alkyl or aryl; R_{96} is alkyl or aryl; p is 1 to 12.

21. The device of claim 20, wherein at least one silane has a structure selected from a group consisting of structures represented by formula II-a.

22. The device of claim 20, wherein at least one silane has a structure selected from a group consisting of structures represented by formula II-b.

23. The device of claim 20, wherein at least one silane has a structure selected from a group consisting of structures represented by formula II-c.

24. The device of claim 20, wherein at least one of the R_1, R_2, R_3, Z_1, Z_2, and Z_3 includes an organic spacer, the organic spacer being an alkylene, alkylene oxide or a bivalent ether group.

25. The device of claim 20, wherein at least one of the R_1, R_2, R_3 includes a halogenated alkyl, a halogenated aryl or a halogenated alkoxy.

26. The device of claim 1, wherein the salt is a lithium salt.

27. The device of claim 1, wherein the concentration of alkali metal salt is about 0.3 to 2.0 M.

28. The device of claim 1, wherein the salt is chosen from the group consisting of: $LiClO_4$, $LiBF_4$, $LiAsF_6$, $LiPF_6$, $LiCF_3SO_3$, $Li(CF_3SO_2)_2N$, $Li(CF_3SO_2)_3C$, $LiN(SO_2C_2F_5)_2$, lithium alkyl fluorophosphates, lithium bis(chelato)borates, and mixtures thereof.

29. The device of claim 1, wherein the electrolyte further includes:
at least one additive selected from the group consisting of: vinyl carbonate, vinyl ethylene carbonate, ethylene sulfite, 1,3 dimethyl butadiene, styrene carbonate, aromatic carbonates, vinyl pyrrole, vinyl piperazine, vinyl piperidine, vinyl pyridine, and mixtures thereof.

30. The device of claim 1, wherein the electrolyte includes a lithium(oxalato)borate (LiBOB) salt and one or more additives selected from a group consisting of VC and VEC.

31. The device of claim 1, wherein the device is lithium secondary battery comprising:
a lithium metal oxide cathode;
a porous separator; and
a carbon or lithium metal anode.

32. The device of claim 31, wherein the cathode includes a material chosen from the group consisting of: Li_xVO_y, $LiCoO_2$, $LiNiO_2$, $LiNi_{1-x}Co_yMe_zO_2$, $LiMn_{0.5}Ni_{0.5}O_2$, $LiMn_{0.3}Co_{0.3}Ni_{0.3}O_2$, $LiFePO_4$, $LiMn_2O_4$, $LiFeO_2$, $LiMc_{0.5}Mn_{1.5}O_4$, vanadium oxide, and mixtures thereof, wherein Me is Al, Mg, Ti, B, Ga, or Si, and Mc is a divalent metal.

33. The device of claim 31, wherein the anode includes a material chosen from the group consisting of: graphite, carbon, $Li_4Ti_5O_{12}$, tin alloys, silica alloys, intermetallic compounds, lithium metal, and mixtures thereof.

34. The device of claim 1, wherein the electrolyte is a liquid.

35. The device of claim 1, wherein the electrolyte is a solid.

36. The device of claim 35, wherein the electrolyte includes an interpenetrating network.

37. The device of claim 36, wherein the interpenetrating network includes a cross-linked polyacrylates or a cross-linked polymethacrylates.

38. The device of claim 36, wherein a compound selected from the group consisting of an acrylate having two or more functionalities and a methacrylates having two or more functionalities serves as a monomer for a member of the interpenetrating network.

39. The device of claim 38, wherein the monomer is a dialkyl acrylate, dimethacrylate, a diallyl terminated compound or a dialkyl methacrylate.

40. The device of claim 38, wherein the electrolyte includes one or more solid polymers.

41. The device of claim 40, wherein at least one of the solid polymers is selected from the group consisting of polyacrylonitrile (PAN), poly(methyl methacrylate) (PMMA), poly(vinylidene fluoride) (PVDF), poly(vinylidene fluoride-co-hexafluoropropylene), polystyrene, polyvinyl chloride, poly(alkyl methacrylate), poly(alkyl acrylate), styrene butadiene rubber (SBR), poly(vinyl acetate), poly(ethylene oxide) (PEO) and mixtures thereof.

42. The device of claim 1, wherein the electrolyte has an ionic conductivity greater than 1.0 x 10^{-4} S/cm at 25 °C.

43. The device of claim 1, wherein the electrolyte has an ionic conductivity greater than 4.0 x 10^{-4} S/cm at 25 °C.

44. A method of forming an electrochemical device, comprising:

forming an electrolyte including one or more polysiloxanes, one or more alkali metal salts, and one or more silanes; and

activating at least one anode and at least one cathode with the electrolyte.

45. The method of claim 44, wherein at least one polysiloxane is cyclic.

46. The method of claim 44, wherein at least one polysiloxane has a backbone that includes one or more silicons linked to one or more side chains that include a poly(alkylene oxide) moiety.

47. The method of claim 46, wherein one or more of the backbone silicons are linked to a plurality of side chains that each include a poly(alkylene oxide) moiety.

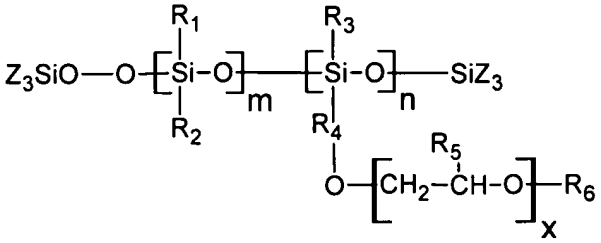
48. The method of claim 46, wherein an organic spacer is positioned between the backbone silicons and the poly(alkylene oxide) moiety.

49. The method of claim 46, wherein the spacer includes an oxygen linked to the backbone silicons.

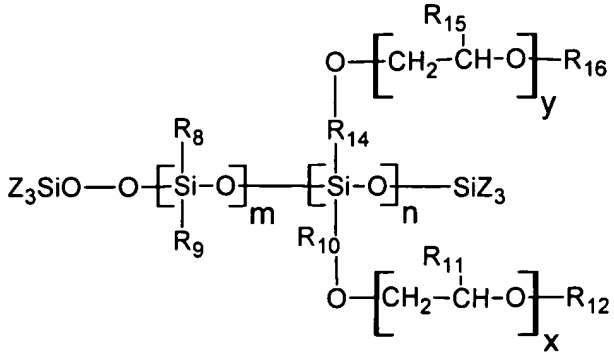
50. The method of claim 44, wherein the silane includes at least one substituent that includes a moiety selected from a first group consisting of an alkyl group, a halogenated alkyl group, an aryl group, a halogenated aryl group, an alkoxy group and an oxyalkylene group and at least one substituent that includes a moiety selected from a second group consisting of an alkoxy group, an oxyalkylene group or a cyclic carbonate group.

51. The method of claim 50, wherein the silane includes four substituents that each includes a moiety selected from the first group or from the second group.

52. The method of claim 44, wherein at least one polysiloxane has a structure selected from a group consisting of structures represented by formula I-a through formula I-d:

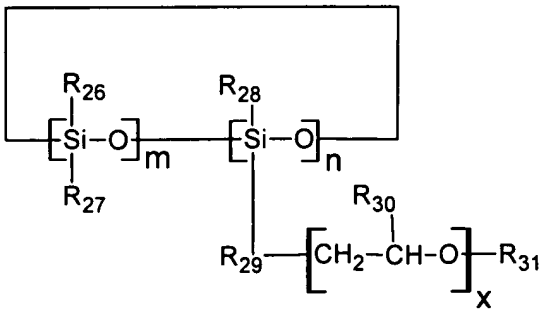


formula I-a: where R_1 is an alkyl group, R_2 is an alkyl group or an alkoxy group, R_3 is an alkyl group, R_4 is nil or an organic spacer, R_5 is a hydrogen atom or an alkyl group, and R_6 are alkyl groups, Z is an alkyl or an aryl group, m is from 0 to 15, n is from 1 to 30, x is from 2 to 15;

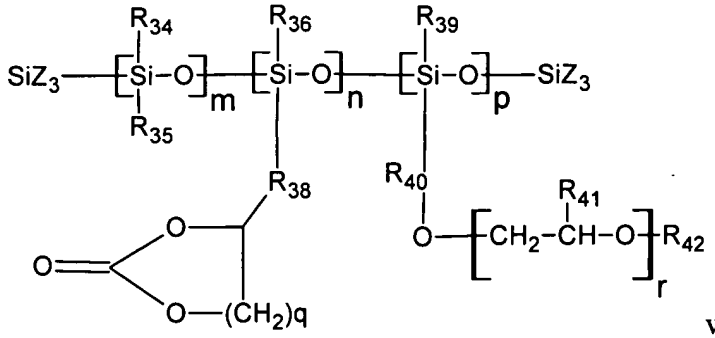


formula I-b: wherein R_8 is an alkyl group, R_9 is an alkyl group or an alkoxy group, R_{10} is nil or an organic spacer, R_{11} is a hydrogen or an

alkyl group, R_{12} is an alkyl group, R_{14} is nil or an organic spacer, R_{15} is a hydrogen or an alkyl group, R_{16} is an alkyl group, Z is an alkyl or an aryl group, m is from 0 to 15, n is from 1 to 30, x is from 2 to 15; and



formula I-c: wherein, R_{26} is an alkyl group, R_{27} is an alkyl group or an alkoxy group, R_{28} is an alkyl group, R_{29} is an oxygen or an organic spacer, R_{30} is a hydrogen atom or an alkyl group, R_{31} is alkyl group, m is 0 or greater than 0, n is from 3 to 10, and x is from 2 to 15; and



formula I-d: where, R_{34} is an alkyl group; R_{35} is an alkyl group or an alkoxy group; R_{36} is an alkyl group; R_{38} is nil an oxygen or an organic spacer; R_{39} is an alkyl group; R_{40} is nil or an organic spacer; R_{41} is a hydrogen or an alkyl group; R_{42} is an alkyl group; Z is an alkyl or an aryl group; m is 0 or greater than 0; n is 1 to 30; p is 0 or greater than 0; q is 1 or 2; r is 2 to 15.

53. The method of claim 52, wherein m is 0.

54. The method of claim 52, wherein R_4, R_{10}, $R1_{14}$, R_{29}, R_{38} and R_{40}, are nil.

55. The method of claim 52, wherein R_4, R_{10}, $R1_{14}$, R_{29}, R_{38} and R_{40}, are an organic spacer.

56. The method of claim 55, wherein the organic spacer includes an oxygen linked to a silicon on the backbone of the polysiloxane.

57. The method of claim 52, wherein at least one polysiloxane has a structure selected from the group consisting of structures represented by formula I-a.

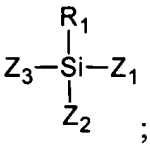
58. The method of claim 52, wherein at least one polysiloxane has a structure selected from the group consisting of structures represented by formula I-b.

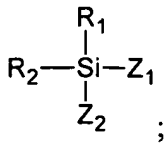
59. The method of claim 52, wherein at least one polysiloxane has a structure selected from the group consisting of structures represented by formula I-c.

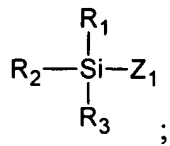
60. The method of claim 52, wherein at least one polysiloxane has a structure selected from the group consisting of structures represented by formula I-d.

61. The method of claim 60, wherein p is 0.

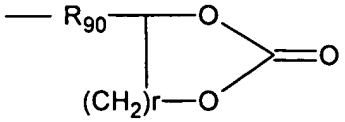
62. The method of claim 44, wherein at least one silane is selected from a group represented by formula II-a through formula II-c:

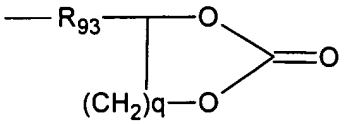
formula II-A:  ;

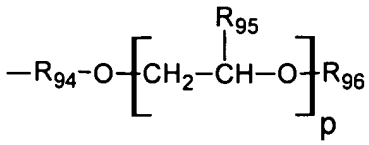
formula II-B:  ;

formula II-C:  ; wherein, R_1 is an alkyl, aryl, an alkoxy, or is represented by formula II-D; R_2 is an alkyl, aryl, an alkoxy or is represented by formula II-D; R_3 is an alkyl, aryl, an alkoxy, or is represented by formula II-D; Z_1 is an alkoxy, is represented by formula II-E or is

represented by formula II-F; Z_2 is an alkoxy, is represented by formula II-E or is represented by formula II-F; Z_3 is an alkoxy, is represented by formula II-E or is represented by formula II-F;

formula II-D:  : wherein R_{90} is oxygen or an organic spacer and r is 1 or 2;

formula II-E:  : wherein R_{93} is oxygen or an organic spacer and q is 1 or 2; and

formula II-F:  : wherein R_{94} is nil or an organic spacer; R_{95} is hydrogen; alkyl or aryl; R_{96} is alkyl or aryl and p is 1 to 12.

63. The method of claim 62, wherein at least one silane has a structure selected from a group consisting of structures represented by formula II-a.

64. The method of claim 62, wherein at least one silane has a structure selected from a group consisting of structures represented by formula II-b.

65. The method of claim 62, wherein at least one silane has a structure selected from a group consisting of structures represented by formula II-c.

66. The method of claim 44, wherein the electrolyte includes at least one additive selected from the group consisting of: vinyl carbonate, vinyl ethylene carbonate, ethylene sulfite, 1,3 dimethyl butadiene, styrene carbonate, aromatic carbonates, vinyl pyrrole, vinyl piperazine, vinyl piperidine, vinyl pyridine, and mixtures thereof.

67. The method of claim 44, wherein at least one cathode is a lithium metal oxide cathode and at least one anode is a carbon or lithium metal anode.

68. The method of claim 44, wherein at least one cathode includes a material chosen from the group consisting of: $LiCoO_2$, $LiNiO_2$, $LiNi_{1-x}Co_yMe_zO_2$, $LiMn_{0.5}Ni_{0.5}O_2$, $LiMn_{0.3}Co_{0.3}Ni_{0.3}O_2$, $LiFePO_4$, $LiMn_2O_4$, $LiFeO_2$, $LiMc_{0.5}Mn_{1.5}O_4$, vanadium oxide, and mixtures thereof, wherein Me is Al, Mg, Ti, B, Ga, or Si, and Mc is a divalent metal.

69. The method of claim 44, wherein at least one anode includes a material chosen from the group consisting of: graphite, carbon, $Li_4Ti_5O_{12}$, tin alloys, silica alloys, intermetallic compounds, lithium metal, and mixtures thereof.

70. The method of claim 44, wherein the electrolyte is a liquid.

71. The method of claim 44, wherein the electrolyte is a solid.

72. The method of claim 44, wherein forming the electrolyte includes forming an interpenetrating network.